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Research Paper

Theory of mind, emotion recognition and social perception in individuals at clinical high risk for psychosis: Findings from the NAPLS-2 cohort

Mariapaola Barbato [a], Lu Liu [a], Kristin S. Cadenhead [b], Tyrone D. Cannon [c], Barbara A. Cornblatt [d], Thomas H. McGlashan [e], Diana O. Perkins [f], Larry J. Seidman [g], Ming T. Tsuang [b,h], Elaine F. Walker [i], Scott W. Woods [e], Carrie E. Bearden [j], Daniel H. Mathalon [k,l], Robert Heinssen [m], Jean Addington [a,*]

[a] Hotchkiss Brain Institute, Department of Psychiatry, University of Calgary, 3280 Hospital Drive NW, Calgary, AB T2N4Z6, Canada
[b] Department of Psychiatry, University of California at San Diego, 140 Arbor Drive, La Jolla, CA 92103, United States
[c] Department of Psychology, Yale University, Box 208205, New Haven, CT 06520-8205, United States
[d] Department of Psychiatry, Zucker Hillside Hospital, 75-59 263rd St., Queens, NY 11004, United States
[e] Department of Psychiatry, Yale University, 300 George St., Suite 901, New Haven, CT 06511 United States
[f] Department of Psychiatry, University of North Carolina, 101 Manning Dr, Chapel Hill, NC 27514, United States
[g] Department of Psychiatry, Harvard Medical School at Beth Israel Deaconess Medical Center and Massachusetts General Hospital, Landmark Building, 401 Park Drive, 2 East, Boston, MA 02215, United States
[h] Institute of Genomic Medicine, University of California, San Diego, 9500 Gilman Drive #0761, La Jolla, CA 92093-0761, United States
[i] Department of Psychology, Emory University, 487 Psychology Building, 36 Eagle Row, Atlanta, GA 30322, United States
[j] Department of Psychiatry and Biobehavioral Sciences and Psychology, University of California, Los Angeles, 300 Building Medical Plaza, Suite 2265, Los Angeles, CA 90095, United States
[k] Department of Psychiatry, University of California at San Francisco, 401 Parnassus Avenue, San Francisco, CA 94143, United States
[l] Psychiatry Service, 116d, San Francisco VA Medical Center, 4150 Clement St. San Francisco, CA 94121, United States
[m] Division of Adult Translational Research and Treatment Development, National Institute of Mental Health, 6001 Executive Boulevard, Room 7141, Bethesda, MSC 9629, United States

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ABSTRACT

Social cognition, the mental operations that underlie social interactions, is a major construct to investigate in schizophrenia. Impairments in social cognition are present before the onset of psychosis, and even in unaffected first-degree relatives, suggesting that social cognition may be a trait marker of the illness.

In a large cohort of individuals at clinical high risk for psychosis (CHR) and healthy controls, three domains of social cognition (theory of mind, facial emotion recognition and social perception) were assessed to clarify which domains are impaired in this population.

Six-hundred and seventy-five CHR individuals and 264 controls, who were part of the multi-site North American Prodromal Longitudinal Study, completed *The Awareness of Social Inference Test*, the *Penn Emotion Recognition task*, the *Penn Emotion Differentiation task*, and the *Relationship Across Domains*, measures of theory of mind, facial emotion recognition, and social perception, respectively.

Social cognition was not related to positive and negative symptom severity, but was associated with age and IQ. CHR individuals demonstrated poorer performance on all measures of social cognition. However, after controlling for age and IQ, the group differences remained significant for measures of theory of mind and social perception, but not for facial emotion recognition.

Theory of mind and social perception are impaired in individuals at CHR for psychosis. Age and IQ seem to play an important role in the arising of deficits in facial affect recognition. Future studies should examine the stability of social cognition deficits over time and their role, if any, in the development of psychosis.

1. Introduction

Social cognition can be defined as the mental operations that underlie social interactions. It includes mental state attribution, affect recognition, attributional style and social perception. It is well known that in schizophrenia, deficits in social cognition are seen at all stages of the illness (Green et al., 2012a) and are relatively stable (Horan et al., 2012). There is also evidence showing that impairments in social cognition are present before the onset of psychosis (Green et al., 2012a), and in unaffected first degree relatives, suggesting that social cognition may be a trait marker of the illness (Lavoie et al., 2013). Using modeling techniques, some studies have shown that, in patients with schizophrenia, social cognition is related to both neurocognition and functional outcome, suggesting that social cognition plays a mediational role between them (Addington et al., 2010; Green et al., 2012b; Schmidt et al., 2011).

Recent progress in risk identification methodology has made it possible to identify individuals who are at clinical high risk (CHR) of

* Corresponding author at: Mathison Centre for Mental Health Research & Education, University of Calgary, 3280 Hospital Drive NW, Calgary, Alberta T2N 4Z6, Canada.
E-mail address: jmadding@ucalgary.ca (J. Addington).

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developing psychosis based on clinical phenomenology, in particular sub-threshold psychotic symptoms (Addington and Heinssen, 2012). It has been reported that compared to healthy controls, CHR individuals show deficits in social cognition similar to those observed in patients at the first episode of psychosis and patients who have a more chronic course of schizophrenia (Green et al., 2012a; Thompson et al., 2011). These deficits are observed in several domains of social cognition, such as theory of mind (ToM), emotion recognition, social perception and attributional style (Addington and Barbato, 2015).

ToM is the ability to attribute beliefs and intentions to oneself and others. Numerous studies, using a variety of ToM tasks, have shown that ToM, is impaired in individuals at CHR (Chung et al., 2008; Green et al., 2012a; Hur et al., 2013; Thompson et al., 2012), although a few studies have not observed impaired ToM (Brüne et al., 2011; Couture et al., 2008; Stanford et al., 2011). In most of these studies, participants were asked to read short stories or cartoons and perform a first or second order mental state attribution, which means inferring the mental state of a character in the story, or inferring the character's beliefs about another character. However, another important aspect of ToM is the ability to process counterfactual information, for example detecting sarcasm or lies. In everyday social interactions, sarcasm and lie detection entails going beyond the literal meaning of a message by using social cues. The only study to date examining how CHR individuals process counterfactual information reported impaired detection of sarcasm and lies (Green et al., 2012a).

Emotion recognition is the ability to recognize other people's feelings. Most studies examining emotion recognition in CHR individuals have focused on prosody and facial affect processing. Although the majority of studies observed deficits in emotion recognition in CHR individuals when compared to healthy controls (Addington et al., 2008; Amminger et al., 2012; Comparelli et al., 2013; Green et al., 2012a; Kohler et al., 2014; van Rijn et al., 2011; Wölwer et al., 2012), mixed findings have been reported, with some studies not finding a deficit (Gee et al., 2012; Pinkham et al., 2007; Seiferth et al., 2008; Thompson et al., 2012) and others showing selective deficits in a sub-set of negative emotions (Amminger et al., 2011). Studies that did not find a significant deficit in emotion recognition tended to have smaller samples, typically less than 20 participants.

Social perception generally refers to the awareness of cues and rules that occur in social situations. There are three studies that have examined social perception in individuals at CHR as compared to healthy controls (Couture et al., 2008; Green et al., 2012a; Thompson et al., 2012), although each of them focused on different aspects of social perception. Findings from the PREDICT study showed that CHR individuals had biased complex social judgements compared to healthy controls (Couture et al., 2008) and to a help-seeking control sample (Healey et al., 2013). Green and colleagues looked at perception of social relationships and demonstrated poorer performance for the CHR group compared to the control group (Green et al., 2012a). Thompson et al. (2012), using the Managing Emotions branch of the Mayer–Salovey–Caruso Emotional Intelligence Test (MSCEIT; Mayer et al., 2002), did not find that their CHR sample evidenced impairment. Although the Managing Emotions section of the MSCEIT includes questions about perception of social or interpersonal situations, the MSCEIT is usually considered a measure of emotional intelligence, that is, the ability to understand and manage emotions and to problem-solve on the basis of them (Mayer et al., 1999), and therefore may not necessarily measure social perception.

Attributional style is an individual's tendency when inferring the cause of an event. A few studies have looked at attributional style in CHR individuals (An et al., 2010; DeVylder et al., 2013; Thompson et al., 2013). Although DeVylder and colleagues did not find an attributional bias in individuals at CHR compared to controls, An and colleagues reported a perceived hostility bias and Thompson and colleagues observed a significantly more externalized locus of control for the CHR group compared to controls.

In summary, although there has been a significant increase in the number of studies assessing social cognition in the CHR population, often samples have been small, results have been mixed, and many studies examined only one or two domains. The current study aimed to expand upon previous research by examining, in a large cohort of individuals at CHR for psychosis and healthy controls, whether social cognition is impaired. It has been observed that the majority of individuals who present as being at CHR and who do not make the transition to psychosis continue to have deficits in social function (Addington et al., 2011), plus there is a link between social cognition and social functioning. It would therefore be important to have an improved understanding of these early deficits in social cognition in the CHR population as a whole so that potential treatments at this pre-psychotic phase could be developed. We assessed three well-established areas of social cognition: ToM (including sarcasm and lies detection), facial affect processing and social relationship perception. Based on the previous literature, we expected to observe a poorer performance in all three domains of social cognition in the CHR group compared to the control group.

2. Methods

2.1. Participants

All participants were recruited as part of the multi-site NIMH funded North American Prodrome Longitudinal Study 2 (NAPLS 2) (Addington et al., 2012) which was established to investigate predictors and mechanisms of conversion to psychosis. The NAPLS 2 sample consists of 764 CHR individuals (436 males, 328 females) and 280 controls (141 males, 139 females) recruited from all eight NAPLS 2 sites (University of California Los Angeles, Emory University, Harvard University, Zucker-Hillside Hospital, University of North Carolina, University of California San Diego, University of Calgary, Yale University). All CHR participants were required to meet the Criteria of Prodromal Syndromes (COPS) using the Structured Interview for Prodromal Syndromes (SIPS) (McGlashan et al., 2010). Participants were excluded if they met criteria for any current or lifetime axis I psychotic disorder, had IQ < 70, or had past or current history of a clinically significant central nervous system disorder. Control participants were excluded if they had a first-degree relative with a current or past psychotic disorder. A more detailed description of ascertainment, inclusion and exclusion criteria, and participant details is provided elsewhere (Addington et al., 2012).

2.2. Measures

The Structured Interview for Prodromal Syndromes (SIPS) (McGlashan et al., 2010) was used to determine whether an individual met criteria for the prodromal syndrome. The Scale of Prodromal Symptoms (SOPS) was used to rate the severity of symptoms and consists of 19 items in 4 symptom domains: positive, negative, general, and disorganized.

IQ was assessed with the Vocabulary and Block Design subtests of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999).

We assessed three well-established areas of social cognition, namely ToM, facial affect processing and social perception, using measures that have now been deemed appropriate for this population, as suggested by the RAND panel (Pinkham et al., 2014). Furthermore, we chose a range of measures that may have particular relevance for social interactions. In particular, we used a recently developed measure of relationship perception, given that vulnerability to psychosis had previously been linked to maladaptive ways of understanding and implementing social relationships (Allen et al., 2005).Theory of mind (ToM) was assessed using the Social Inference subscale of The Awareness of Social Inference Test (TASIT; McDonald et al., 2003a,b); facial affect processing was assessed with the Penn Emotion Recognition task (ER40; Gur et al., 2002) and the Penn Emotion Differentiation task (EDF40; Kohler et al.,

2000); and social perception was assessed using the abbreviated version of the Relationship Across Domains (RAD; Sergi et al., 2009).

The Social Inference subscale of the TASIT includes 16 short video scenes, enriched with contextual cues, where actors are engaged in everyday conversations and use lies and sarcasm. In half of the vignettes the main speaker conveys a message that is contrary to what he or she believes (i.e., a lie), and in the other half the main speaker says something that is contrary to the actual meaning he or she wishes to convey (i.e., sarcasm). After each scene, participants answer questions about what the characters are thinking, doing, feeling and saying. Participants can answer "yes", "no" or "don't know". For each scene, the maximum score is four, yielding a maximum score of 64 as well as subscores for Lies and Sarcasm. The TASIT is an audiovisual measure with good psychometric properties (McDonald et al., 2006) and high ecological validity (McDonald et al., 2004). Although it was initially developed for use with patients with traumatic brain injury, its efficacy in detecting ToM deficits has been proven with both schizophrenia patients (Cassetta and Goghari, 2014; Green et al., 2012a; Kern et al., 2009; Sparks et al., 2010) and individuals at CHR (Green et al., 2012a).

To assess facial affect processing, two well-established computerized tasks, the ER40 and the EDF40, were used. In these tasks, pictures representing facial expressions are shown in color. There are an equal number of male and female faces, and four races are represented (Caucasian, African–American, Asian and Hispanic). In the ER40, one face at a time is shown and participants have to choose the emotion that is represented from a list of five possibilities (anger, fear, neutral, happy and sad), shown on the right side of the screen. In the EDF40, two faces are shown and participants are asked to indicate which one shows an emotion (either happiness or sadness) more intensely. For the ER40 task, there are a total score ranging from 0 to 40, and individual sub-scores for happy, sad, angry, fearful and neutral facial expressions. For the EDF40 task, there are a total score ranging from 0 to 40, and two sub-scores for happy and sad facial expressions. Both of these tasks have been previously used with schizophrenia patients (Goghari and Sponheim, 2013; Silver et al., 2004; Weiss et al., 2007) and individuals at CHR (Kohler et al., 2014).

The RAD is a measure of competence in relationship perception. The full version of the RAD has 25 vignettes and 75 items. For the purpose of this study, we used the RAD-45 items, an abbreviated version of the RAD. The RAD-45 contains 15 vignettes each involving two characters whose interpersonal behaviors are consistent with one of the four relational models (Fiske, 1991, 2004). According to the relational model theory, people base their relationships on four implicit relationship models that regulate social behavior in several different domains of social life. Relationships conforming to the first model, named Communal Sharing, are based on the idea that the individuals have something in common and are equivalent and undifferentiated. The second model is called Authority Ranking and refers to relationships where there is a hierarchy between the members, which can be classified into "decision makers" and "followers". The third model is called Equality Matching and is based on relationships involving a one-to-one distribution of efforts and resources between members. In the fourth model, called Market Pricing, relationships are based on ratios and rates, and members are focused on proportionality based on their contribution to a certain activity or business. In the RAD, each vignette is followed by three statements that describe interactions between the same two characters in different situations, with each statement representing one of the relational models. Participants are asked to use the information they have learned from the vignette to judge (answering yes/no) whether the behaviors described in each statement are likely to occur. Performance is measured as the total number of correct responses (ranging from 0 to 45) and four sub-scores, one for each relational model named above. The RAD has good psychometric properties and was specifically developed and validated to assess perception of relationships in individuals with schizophrenia (Sergi et al., 2009) based on evidence showing a link between poor use of relationship models and vulnerability to psychosis (Allen et al., 2005).

2.3. Procedures

All sites recruited both CHR individuals and healthy controls. The study was approved by the Institutional Review Boards of all eight NAPLS 2 sites. Informed consent was obtained from those who met criteria and were judged fully competent to give consent. Parental consent was obtained from parents/guardians of minors. Participants were assigned a clinical rater who conducted all the semi-structured interviews. Raters were experienced research clinicians. Gold standard post-training agreement on determining the prodromal diagnoses was excellent (kappa = 0.90) (Addington et al., 2012). Social cognition assessments were conducted at all sites by research assistants and postdoctoral fellows trained by J. Addington. All data in this study were collected at the initial assessment of the NAPLS 2 project.

2.4. Statistical analysis

Demographic variables were compared between the two groups using the Student's t-test and Chi-square test. The Spearman rank–order correlation coefficient was used to assess, within each group, the correlation between measures of social cognition, as well as the correlation of social cognition with clinical symptoms, and age. To account for multiple comparisons, Bonferroni correction was applied. The distribution of the social cognition data was negatively skewed. For all variables results of the Shapiro–Wilk test were statistically significant at the p-level of 0.0001. Skewness and Kurtosis were statistically significant for most of the variables. Our attempts to transform the data to symmetry were not successful. Therefore Mann–Whitney U test was initially used to test for differences in social cognition between the CHR group and the control group. To account for the skewed data, for which means are not an adequate measure of central tendency because of their sensitivity to outliers, median regression models were used to assess the difference in social cognition between the CHR group and the control group controlling for age, as well as the differences between the CHR group and the control group controlling for IQ. Median regression is a statistical method for modeling the relation between a set of predictor variables and the conditional median of the response variable (Koenker and Bassett, 1978), yielding estimates that are more robust against outliers in the response measurements, relative to the ordinary least squares regression.

3. Results

The sample of participants in NAPLS 2 that completed the social cognition assessments included 675 CHR individuals (389 males and 286 females) and 264 controls (136 males and 128 females). Control participants were slightly older and had significantly more years of education than CHR participants. IQ was higher in the control group (Median = 111, SD = 14.10; U = 61557) compared to the CHR group (Median = 105, SD = 15.28, $p < 0.0001$). The characteristics of the sample are summarized in Table 1.

In both groups, the total scores of all measures of social cognition were inter-related and there were significant positive correlations between social cognition and age and between social cognition and IQ (Table 2). We examined the associations of social cognition with the SOPS total positive symptoms and total negative symptoms. There were no significant correlations between any of the social cognition measures and symptoms.

Results of the initial comparisons between groups are shown in Table 3. Median regression models were used to further explore the significant group differences controlling for age and controlling for IQ. The

Table 1
Demographic characteristics.

Variable	CHR $n = 675$	Controls $n = 264$	Test Statistic
	Mean (SD)		*t*
Age (years)	18.49 (4.25)	19.77 (4.72)	3.84*
Years of education	11.28 (2.80)	12.70 (3.60)	5.77*
	Frequency (%)		χ^2
Sex			
Male	389 (57.6%)	136 (51.5%)	2.88
Female	286(42.4%)	128 (48.5%)	
Race			
Latin America/Middle East/White	425 (63.0%)	157 (59.5%)	7.38
Black	105 (15.6%)	48 (18.2%)	
Asian	46 (6.9%)	26 (9.8%)	
Interracial	82 (12.2%)	28 (10.6%)	
Native American	13 (1.9%)	4 (1.5%)	
Native Hawaiian or Pacific Islander	3 (0.4%)	1 (0.4%)	
Marital Status			
Single never married	642 (95.3%)	251 (95.1%)	5.65
Other[a]	32 (4.8%)	13 (5.0%)	
Currently working			
Yes	169 (25.1%)	122 (46.2%)	42.48*
No	504 (74.8%)	142 (53.8%)	
Currently enrolled as a student			
Yes	557 (82.8%)	212 (80.3%)	0.78
No	116 (17.2%)	52 (19.7%)	

* $p < 0.01$.
[a] Married, divorced, separated, widowed or cohabiting with a significant other.

Table 3
Social cognition between groups.

Measure	Group *Mean (SD)*		Range[a]	Mann–Whitney U	Effect size
	CHR $n = 675$	*Controls* $n = 264$			
TASIT total	52.34 (6.11)	54.79 (5.30)	0–64	65065.50**	−0.19
Lies	26.66 (3.81)	27.93 (3.14)	0–32	68408.00**	−0.16
Sarcasm	25.68 (3.93)	26.87 (3.84)	0–32	69805.00**	−0.15
ER40 total	32.79 (3.54)	33.67 (2.79)	0–40	73849.50*	−0.11
Angry	5.00 (1.45)	5.03 (1.40)	0–8	85429.50	−0.00
Fearful	6.81 (1.33)	6.91 (1.26)	0–8	81984.50	−0.03
Neutral	6.94 (1.71)	7.22 (1.25)	0–8	81619.00	−0.04
Happy	7.68 (0.73)	7.78 (0.48)	0–8	81979.00	−0.04
Sad	6.36 (1.39)	6.73 (1.18)	0–8	72969.00**	−0.12
EDF40 total	24.29 (6.01)	25.97 (5.22)	0–40	73011.50*	−0.11
Happy	10.98 (3.73)	11.96 (3.57)	0–19	72983.50*	−0.11
Sad	13.31 (2.90)	14.01 (2.43)	0–21	75175.00*	−0.09
RAD total	31.68 (5.30)	33.95 (4.48)	0–45	63276.00**	−0.20
Communal	8.98 (2.00)	9.58 (1.86)	0–12	70381.00**	−0.14
Authority	9.35 (2.19)	10.32 (1.59)	0–12	63204.00**	−0.20
Equality	7.48 (1.70)	8.01 (1.65)	0–12	71397.00**	−0.13
Market	5.86 (1.68)	6.04 (1.63)	0–9	79510.50	−0.05

* $p < 0.01$.
** $p < 0.001$.
[a] This range refers to the minimum and maximum score that can be obtained in each measure or sub-score.

results of the analysis controlling for age showed that there were significant differences in medians between the CHR group and the control group in TASIT total, TASIT Sarcasm, TASIT Lies, RAD total, Communal, Authority and Equality. The groups no longer differed in the ER40 and the EDF40. The results of the median regression controlling for IQ showed that there were significant differences in medians between the CHR group and the control group in TASIT total, TASIT Sarcasm, RAD total and RAD Authority. The groups no longer differed in TASIT Lies, the ER40, the EDF, and RAD Communal and Equality. See Tables 4 and 5.

4. Discussion

This is one of the first studies to assess multiple domains of social cognition in a large cohort of individuals at clinical high risk for psychosis (CHR) and healthy controls. Specifically, this study assessed ToM, facial emotion perception and social perception.

The social cognition data were negatively skewed, a result that has been observed in other studies using the same measures (McDonald et al., 2003b; Kohler et al., 2014), suggesting that there may have been a ceiling effect for these measures. Similar distribution of the data was observed in both the CHR group and the healthy control group. Nevertheless, the results of our group comparisons showed a poorer performance for the CHR group compared to controls in all measures of social cognition, possibly indicating that although a proportion of the CHR individuals perform well in social cognition tasks, there may be a sub-group of CHR individuals who have poorer social cognition. Furthermore, despite the ceiling effect, the measures used appear to be sensitive enough to highlight small group differences. Although, when we controlled for age and then for IQ, group differences in ToM and social perception remained significant but there were no longer significant group differences in facial affect recognition.

The observed deficit in ToM ability, as shown by a lower total score on the TASIT, confirms previous evidence that individuals at CHR have difficulties with mental states attribution (Bora and Pantelis, 2013; Chung et al., 2008; Green et al., 2012a; Hur et al., 2013). This result remained significant even after controlling for age, and IQ. Moreover, our study supports the work of Green et al. (2012a), demonstrating that CHR individuals show poor processing of counterfactual information. Specifically, the group differences in sarcasm detection remained significant after controlling for age and for IQ, suggesting that impairment in processing counterfactual information starts early in the course of psychosis and may be considered as an indicator of vulnerability. It may be that deficits in sarcasm detection impede social interaction and the establishment of peer-relationships, thus impacting social functioning. Nevertheless, the small effects sizes observed in the current study may indicate that these deficits are less severe in this population than they are in individuals with an established psychotic illness, supporting evidence that the performance of CHR individuals in ToM falls in between that of first-episode patients and of healthy controls (Bora and Pantelis, 2013).

We initially observed poorer facial emotion recognition in CHR individuals compared to controls, supporting previous literature (Addington et al., 2008; Amminger et al., 2011; Comparelli et al., 2013; Kohler et al., 2014). The group differences in our study were no longer significant after controlling for age, a result only found in one previous study (Thompson et al., 2012). It is not clear why our groups

Table 2
Correlations between measures of social cognition.

Measure	TASIT	ER40	EDF40	RAD
CHR				
ER40	0.22*	–		
EDF40	0.27*	0.17*	–	
RAD	0.52*	0.16*	0.37*	–
AGE	0.21*	0.00	0.24*	0.27*
IQ	0.45*	0.11*	0.40*	0.55*
Controls				
ER40	0.25*	–		
EDF40	0.39*	0.13	–	
RAD	0.41*	0.18	0.33*	–
AGE	0.38*	0.17	0.17	0.26*
IQ	0.31*	0.11*	0.42	0.46*

* $p < 0.001$.

Table 4
Estimated medians of social cognition measures with adjustments for age.

Measure	CHR n = 675	Controls n = 264	Adjusted difference in medians	
	Median	Median	Estimate (95% CI)	P-value
TASIT total	**54**	**56**	**−2.0 (−3.08, −0.92)**	**<0.0001**
Lies	**27**	**29**	**−1.36 (−1.99, −0.74)**	**<0.0001**
Sarcasm	**26**	**28**	**−0.82 (−1.44, −0.19)**	**0.011**
ER40 total	33	34	−1.0 (−2.08, 0.08)	0.07
Sad	7	7	0.00 (-5.34×10^{-9}, 5.34×10^{-9})	1.00
EDF40 total	25	26	−0.33 (−1.09, 0.42)	0.39
Sad	14	14	−0.10 (−0.53, 0.33)	0.57
Happy	11	12	−0.58 (−1.35, 0.18)	0.136
RAD total	**32**	**35**	**−2.0 (−2.69, −1.31)**	**<0.0001**
Communal	**9**	**10**	**−0.62 (−0.91, −0.33)**	**<0.0001**
Authority	**10**	**11**	**−0.67 (−1.05, −0.29)**	**0.001**
Equality	**7**	**8**	**−0.57 (−0.94, −0.21)**	**0.002**

no longer significantly differed once age was considered in the model, particularly when most previous studies are reporting such differences. However, even amongst the studies cited above that observed deficits in facial emotion recognition after controlling for age, results are mixed with regard to individual emotions that may be affected. It has been suggested that facial affect processing can vary significantly during the adolescence period due to continuous and non-linear development of the specific brain regions involved in facial affect processing (Blakemore, 2008; Burnett et al., 2011), and therefore high variability might be expected when assessing facial emotion processing in adolescence, which could result in mixed findings when comparing outcomes across studies. Similarly, the group differences in facial emotion recognition were no longer significant after controlling for IQ. To date, only two studies considered the influence of IQ on emotion recognition, and they had different results. The first (Thompson et al., 2012) found no differences between CHR and healthy controls, whereas the second (Amminger et al., 2011) found impaired recognition of fear and sadness in their at-risk group. Based on our results it is possible that, for individuals at CHR, IQ has an impact on facial affect recognition, however, given the limited number of studies that looked at the relationship between IQ and facial affect recognition, a definite statement cannot be made at this stage. In our study the effect sizes for group differences in facial affect recognition were small, perhaps because the CHR participants were demonstrating only mild impairment or because some were performing at a normal level. This fits with previous work (Addington et al., 2008), demonstrating that on facial affect recognition CHR individuals performed better than schizophrenia patients and worse than controls, but without significantly differing from either.

Social perception was impaired in the CHR group, confirming findings from previous studies (Couture et al., 2008; Green et al., 2012a; Healey et al., 2013). It is worth noting that social perception assessments typically consider the awareness of cues that occur in social situations (Addington et al., 2006); however, studies to date assessing social perception in CHR individuals have typically considered only one aspect of social perception. In this study, we have examined the understanding of social relationships, as assessed by the RAD, and our results are supported by two other studies that demonstrated poor performance on the RAD for both schizophrenia (Green et al., 2012a; Sergi et al., 2009) and CHR samples (Green et al., 2012a). Furthermore, after controlling for IQ, we observed group differences in RAD Authority. Interestingly, in the RAD, the Authority Ranking relationship model refers to relationships where there is a hierarchy between the members. Inappropriate use of this relationship model has been found to be associated with psychosis proneness (Allen et al., 2005) and schizotypal personality (Haslam et al., 2002), in support of our findings.

Finally, there were no relationships between symptoms and social cognition, which is similar to several prior reports (Couture et al., 2008; Stanford et al., 2011; Yong et al., 2014), although a link between symptom progression and social cognition has been reported (Allott et al., 2014; Healey et al., 2013; Kim et al., 2011). In the literature, the evidence for a relationship between social cognition and symptoms is mixed, and this could at least in part be due to the use of different measures to assess both symptoms and social cognition. It is interesting to note that no relationship was observed in previous studies that used the SOPS to assess symptoms (Couture et al., 2008; Stanford et al., 2011; Yong et al., 2014).

Table 5
Estimated medians of social cognition measures with adjustments for IQ.

Measure	CHR n = 675	Controls n = 264	Adjusted difference in medians	
	Median	Median	Estimate (95% CI)	P-value
TASIT total	**54**	**56**	**−1.00 (−1.97, −0.031)**	**0.043**
Lies	27	29	−0.62 (−1.24, 0.01)	0.055
Sarcasm	**26**	**28**	**−0.83 (−1.41, −0.25)**	**0.005**
ER40 total	33	34	−0.49 (−1.03, 0.05)	0.076
Sad	7	7	0.00 (-5.34×10^{-9}, 5.34×10^{-9})	1.00
EDF40 total	25	26	−0.11 (−1.11, 0.89)	0.83
Sad	14	14	−0.18 (−0.36, 0.73)	0.509
Happy	11	12	−0.38 (−0.99, 0.23)	0.22
RAD total	**32**	**35**	**−0.91 (−1.75, −0.06)**	**0.035**
Communal	9	10	−0.20 (−0.57, 0.17)	0.29
Authority	**10**	**11**	**−0.39 (−0.65, −0.13)**	**0.003**
Equality	7	8	−0.15 (−0.47, −0.16)	0.335

The strengths of our study include a large well-defined sample and the assessment of three domains of social cognition. Limitations of our study include the fact that we used only one measure of social cognition per domain, and that our results are cross-sectional.

In conclusion, we have demonstrated that ToM and social perception are impaired in the CHR population. Since social cognitive deficits impact social functioning addressing these difficulties at the early stage may have implications for later functioning. Next steps are to examine the stability of social cognition deficits in CHR individuals and to evaluate their predictive relationships with later conversion to psychosis.

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Contributors

Drs. Addington, Cadenhead, Cannon, Cornblatt, McGlashan, Perkins, Seidman, Tsuang, Walker, Woods, Bearden, Mathalon, and Heinssen were responsible for the design of the study and for the supervision of all aspects of data collection. Dr. Barbato contributed to data collection and supervision of same at the Calgary site, and took the lead on writing the manuscripts with help from Dr. Addington. Dr. Barbato and Ms. Liu were responsible for data analysis. All authors contributed to and approved the final manuscript.

Conflict of Interest

There are no conflicts of interest for any of the authors with respect to the data in this paper or for the study.

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